Edexcel IAL Chemistry A-level

Unit 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

Definitions

Definitions and Concepts for Edexcel IAL Chemistry A-level

Energetics, Group Chemistry, Halogenoalkanes and Alcohols

Topic 6: Energetics

Bond enthalpy: The energy required to break one mole of the stated bond in a gaseous state, under standard conditions.

Calorimetry: The process of measuring the amount of energy absorbed or released during a chemical reaction.

Endothermic reaction: A reaction that takes in energy from the surroundings so the temperature of the surroundings decreases. The energy needed to break existing bonds is greater than the energy released from forming new bonds.

Enthalpy change (ΔH): The heat energy change measured under a constant pressure.

Exothermic reaction: A reaction that releases energy to the surroundings so the temperature of the surroundings increases. The energy needed to break existing bonds is less than the energy released from forming new bonds.

Hess's law: The enthalpy change of a reaction is independent of the route taken.

Mean bond enthalpy: The enthalpy change when one mole of a specified covalent bond is broken, averaged out across the range of compounds.

Standard conditions: 100 kPa and a stated temperature (generally 298K).

Standard enthalpy change of atomisation ($\Delta_{at}H^{\ominus}$): The enthalpy change when one mole of gaseous atoms is formed from an element in its standard state under standard conditions.

Standard enthalpy change of neutralisation ($\Delta_{neut}H^{\ominus}$): The enthalpy change when solutions of acid and alkali react together under standard conditions to produce one mole of water.

Standard enthalpy change of reaction ($\Delta_{r}H^{\ominus}$): The enthalpy change when quantities of substances in standard states react completely under standard conditions.

Standard enthalpy of combustion ($\Delta_{c}H^{\ominus}$): The enthalpy change when one mole of a substance is burned in excess oxygen under standard conditions.

Standard enthalpy of formation ($\Delta_{f}H^{\ominus}$): The enthalpy change when one mole of a substance in its standard state under standard conditions is formed from its elements under standard conditions.

Topic 7: Intermolecular Forces

Boiling temperature: The temperature at which a substance changes from a liquid state to a gaseous state.

Hydrogen bonding: An interaction between a hydrogen atom and an electronegative atom, commonly nitrogen, fluorine or oxygen. The slightly positive hydrogen is attracted to the lone pair on the electronegative atom. Hydrogen bonds are stronger than van der Waals and dipole-dipole forces but weaker than ionic and covalent bonds.

Intermolecular forces: The forces which exist between molecules. The strength of the intermolecular forces impact physical properties like boiling/melting point.

Permanent dipole-dipole forces: When molecules with polar covalent bonds interact with dipoles in other molecules dipole-dipole intermolecular forces are produced between the molecules. These intermolecular forces are generally stronger than van der Waals forces but weaker than hydrogen bonding.

Polar bond: A covalent bond between two atoms in which the electrons in the bond are unevenly distributed. This causes a slight charge difference which induces a dipole in the molecule.

Solvent: A substance, generally a liquid, in which other substances dissolve. This forms a solution.

Van der Waals: Also known as induced dipole–dipole, dispersion and London forces, van der Waals forces exist between all molecules. They arise due to fluctuations of electron density within a nonpolar molecule. These fluctuations may temporarily cause an uneven electron distribution, producing an instantaneous dipole. This dipole can induce a dipole in another molecule, and so on.

Topic 8: Redox Chemistry and Groups 1, 2 and 7

8A: Redox Chemistry

Disproportionation reaction: A reaction in which a species is both oxidised *and* reduced, indicated by both an increase and a decrease in oxidation number for that species.

Half equation: A full redox equation can be split into two half-equations, one involving oxidation and the other involving reduction. This concept is useful for balancing complex redox reactions.

Ionic equation: A chemical equation that involves dissociated ions.

Oxidation: Process involving the loss of electrons. Results in an increase in oxidation number.

Oxidation number: The charge of an ion or a theoretical charge of an atom in a covalently bonded compound assuming the bond becomes ionic.

Oxidising agent: Electron acceptors. A species which brings about oxidation by gaining electrons. The oxidising agent is itself reduced.

p-block element: Elements in Groups 3-8/0 of the periodic table. p-block non-metals generally undergo reduction reactions.

Redox reaction: A reaction in which both reduction and oxidation are occurring simultaneously.

Reducing agent: Electron donors. A species which brings about reduction by losing electrons. The reducing agent is itself oxidised.

Reduction: Process involving the gain of electrons. Results in a decrease in oxidation number.

s-block element: Elements in Groups 1 and 2 of the periodic table. These generally undergo oxidation reactions.

8B: The elements of Groups 1 and 2

First ionisation energy: The energy required to remove 1 mole of electrons from 1 mole of gaseous atoms to form 1 mole of gaseous 1^+ ions. For example, $Mg_{(g)} \rightarrow Mg^+_{(g)} + e^-$.

Flame test: An analytical technique used to identify certain elements and ions based on the colour produced when a nichrome wire is dipped into a solution of the species and held in a blue bunsen flame.

Ionisation energy trend: Ionisation energy generally decreases down the group due to atomic radius and shielding increasing. The nucleus, therefore, attracts the outer shell electrons less strongly.

Periodicity: Trends in element properties with increasing atomic number. The trends are caused by the changes in the elements' atomic structure.

Solubility: The ability for a given substance to dissolve in a solvent. Solubility of the Group 2 hydroxides increases down the group and solubility of the Group 2 sulfates decreases down the group.

Test for ammonium ions: Add sodium hydroxide solution and gently warm. Ammonia gas will form, which is basic, and will turn damp red litmus paper blue.

Test for carbonate ions: Add an acid, such as HCl, the substance will fizz as CO_2 is released. This gas can be collected and bubbled through limewater, turning it cloudy.

Test for sulfate ions: Add acidified barium chloride to a solution containing sulfate ions. A white precipitate of barium sulfate is formed.

Thermal decomposition: A reaction in which a chemical substance is broken down by heating.

Thermal stability trend: As you go down the period more heat is required for the thermal decomposition of Group 2 nitrates and carbonates because the ions increase in size and therefore have greater thermal stability.

Uncertainty: The degree of error in a measurement. Different instruments have different uncertainties.

8C: Inorganic chemistry of Group 7 (limited to chlorine, bromine and iodine)

Displacement: A chemical reaction in which one element replaces another element in a compound. A halogen will displace a halide from solution if the halide is below it in the periodic table.

Disproportionation: A reaction in which a substance is simultaneously reduced and oxidised. Chlorine undergoes disproportionation in the reaction with cold, dilute, aqueous sodium hydroxide.

Electronegativity: The tendency of an atom to attract a bonding pair of electrons.

Melting and boiling point trend: The Group 7 elements are simple covalent molecules held together with van der waals forces. The strength of these intermolecular forces increases down the group as the relative atomic mass of the molecule increases. Further down the group more energy is required to overcome the van der waals forces, resulting in higher melting and boiling points.

Oxidising ability: The ability to act as an oxidising agent. The oxidising ability of the halogens decreases down the group. This is because down the group the atoms get larger so the electrons are less strongly attracted to the nucleus so it is harder to gain an electron.

Precipitation reaction: A reaction in which solutions react to form an insoluble product. When combined with acidified silver nitrate, halide ions react to form different coloured precipitates depending on the ion present. The colour of the precipitate formed can be used to identify which halide is present in a solution.

Reactivity trend: The Group 7 elements need to gain an electron in order to react. As atomic radius increases, this becomes harder as the positive attraction of the nucleus is weakened by additional shielding. Therefore, down Group 7 it is harder to attract an electron so reactivity decreases.

Redox reaction: A reaction in which oxidation and reduction occur simultaneously.

Reducing ability: The ability to act as a reducing agent. The reducing ability, or reducing power, of the halides increases down the group. This is because to act as a reducing agent the halide needs to lose an electron. As you go down the group it is easier for a halide to lose an electron because the attraction from the outer electron and nucleus decreases due to increased shielding and an increasing ionic radius.

Topic 9: Introduction to Kinetics and Equilibria

9A: Kinetics

Activation energy: The minimum amount of energy for particles to collide with for a successful reaction to take place.

Catalyst: A substance that increases the rate of a reaction without being changed in chemical composition or amount. They work by providing an alternative reaction pathway with a lower activation energy.

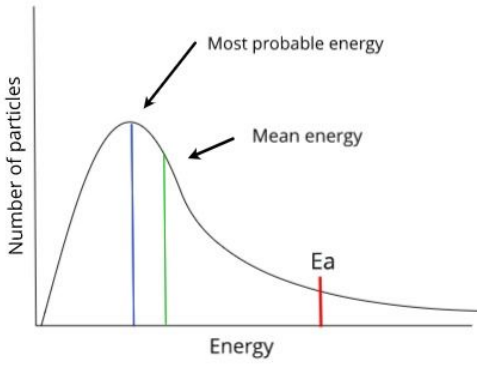
Collision theory: Reactions can only occur when collisions take place between particles that have sufficient energy (activation energy).

Effect of concentration on reaction rate: As the concentration of reactants increases, the reacting particles get closer together meaning they will collide more often. As a result, there will be a higher rate of successful collisions and a faster rate of reaction.

Effect of pressure on reaction rate: As the pressure of gaseous reactants increases, the reacting particles get closer together meaning they will collide more often. As a result, there will be a higher rate of successful collisions and a faster rate of reaction.

Effect of temperature on reaction rate: Increasing the temperature means the particles will have more kinetic energy and so will move faster. If the molecules are moving faster they will collide more often and, since they've gained kinetic energy, a larger proportion of the particles will have at least the activation energy. For both these reasons the rate of reaction increases.

Maxwell-Boltzmann distribution: Shows the distribution of the molecular energies in a gas at a constant temperature. The area under the curve indicates the total number of particles present. Example distribution:



Rate of reaction: The measure of the amount of product formed or reactant used over time. The units of rate of reaction may be given as g/s, cm^3/s or mol/s.

9B: Equilibria

Closed system: A system where there is only heat exchange occurring between the system and its surroundings. No matter can enter or exit the system.

Dynamic equilibrium: Reached by a reversible reaction when the rate of the forward reaction equals the rate of the backward reaction. The concentrations of the reactants and products remain constant.

Effect of changing concentration on equilibrium: If the concentration of a reactant increases, more products will be formed to re-establish the equilibrium.

Effect of changing pressure on equilibrium: If pressure is increased, the position of equilibrium shifts towards the side with the fewest number of molecules. If the pressure is decreased, the position of equilibrium shifts towards the side with the greatest number of molecules to oppose this change.

Effect of changing temperature on equilibrium: If the temperature of a system in equilibrium is increased, there will be an increase in the relative amount of products for an endothermic reaction and a decrease for an exothermic reaction.

Homogeneous system: A system where all the chemicals are in the same phase.

Le Chatelier's principle: If a reaction at equilibrium is subjected to a change in concentration, temperature or pressure, the position of equilibrium will move to counteract the change.

Reversible reaction: A reaction in which the products from the reaction can react together to form the original reactants. The direction of reversible reactions can be changed by changing the conditions.

Topic 10: Organic Chemistry: Halogenoalkanes, Alcohols and Spectra

10A: General Principles

Addition: A reaction in which the reactants combine to form a single product.

Electrophile: A species that can accept electrons in a reaction, to form a chemical bond. Electrophiles are attracted to areas with a lot of electrons/high negative charge.

Elimination: A reaction in which a molecule loses atoms or groups of atoms to form a C=C bond.

Heterolytic bond breaking (heterolytic fission): Bond breaking in which one atom receives both electrons from the breaking of the covalent bond, while the other atom receives none. This bond-breaking forms ions: the atom that gains both of the electrons will form a negative ion and the other atom will form a positive ion.

Hydrolysis: A reaction in which a molecule is broken down by its reaction with water.

Mechanism: A step by step sequence of reactions that occur during a chemical change when reactants are converted to products. Mechanisms show the movement of electrons during the reaction, represented by curly arrows.

Nucleophile: An atom or molecule that donates an electron pair to form a covalent bond. Attracted to electron-deficient areas.

Oxidation: Process involving the loss of electrons. Results in an increase in oxidation number.

Polymerisation: A reaction in which many small molecules known as monomers join together to form a long, repeating molecule called a polymer.

Reduction: Process involving the gain of electrons. Results in a decrease in oxidation number.

Substitution: A reaction in which one functional group is replaced with a different functional group.

10B: Halogenoalkanes

Electronegativity: A measure of the ability of an atom to attract a bonding pair of electrons within a covalent bond. The Pauling scale is often used, with fluorine being the most electronegative element and caesium and francium being the least electronegative elements.

Halogenoalkane: A saturated molecule where one or more of the hydrogen atoms in an alkane have been substituted for a halogen.

Nucleophile: An atom or molecule that donates an electron pair to form a covalent bond. Attracted to electron-deficient areas.

Nucleophilic substitution: A reaction in which an electron pair donor attacks an electrophilic atom (an atom with a partial or full positive charge) to replace an atom/group of atoms.

Polar bond: A covalent bond in which there is an unequal distribution of the electrons between the two atoms due to the differing electronegativities of the bonding atoms. One atom will have a partial positive charge while the other will have a partial negative charge.

Primary halogenoalkane: A halogenoalkane in which the carbon bonded to the halogen is itself only bonded to one other carbon atom.

Secondary halogenoalkane: A halogenoalkane in which the carbon bonded to the halogen is itself bonded to two other carbon atoms.

Tertiary halogenoalkane: A halogenoalkane in which the carbon bonded to the halogen is itself bonded to three other carbon atoms.

10C: Alcohols

Aldehyde: A compound containing the -CHO functional group at the end of an alkyl chain. Aldehydes can be oxidised to carboxylic acids by heating them under reflux with $Cr_2O_7^{2-}$/ H^+.

Combustion: A reaction in which the carbon and hydrogen within fuels are oxidised to release energy and to produce carbon dioxide and water.

Elimination: A reaction in which a molecule loses atoms or groups of atoms to form a C=C bond.

Ketone: A compound containing the C=O functional group within an alkyl chain. Ketones cannot be oxidised further.

Primary alcohol: An alcohol in which the -OH is attached to a primary carbon atom (i.e. RCH_2OH). Primary alcohols can be oxidised with $Cr_2O_7^{2-}/H^+$ to form either an aldehyde or a carboxylic acid, depending on the conditions.

Purification: Techniques used to remove contaminants from a product.

Oxidation: The loss of electron(s) leading to an increase in oxidation number.

Oxidising agent: A species which brings about oxidation by gaining electrons. The oxidising agent is itself reduced.

Reducing agent: A species which brings about reduction by losing electrons. The reducing agent is itself oxidised.

Reduction: The gain of electron(s) leading to a decrease in oxidation number.

Reflux: The continual boiling and condensing of a reaction mixture. This technique is often used to make sure a volatile liquid reaches a high enough temperature to ensure that the reaction goes to completion.

Secondary alcohol: An alcohol in which the -OH is attached to a secondary carbon atom (i.e. R_2CHOH). Secondary alcohols can be oxidised under reflux with $Cr_2O_7^{2-}/H^+$ to form a ketone.

Tertiary alcohol: An alcohol in which the -OH is attached to a tertiary carbon atom (i.e. R_3COH). Tertiary alcohols cannot be oxidised.

Topic 10D: Mass Spectra and IR

Fingerprint Region: The region on an IR spectrum below 1500 cm^{-1} which is unique to each molecule.

Infrared Spectroscopy: An analytical technique used to identify particular bonds and functional groups within a molecule. Infrared spectroscopy can also be used to identify impurities.

Mass spectrometry: A technique used to identify compounds and determine their relative molecular mass.

Molecular ion peak: The peak on a mass spectrum with the highest m/z value, this is used to determine the molecular mass of a compound.

M/Z ratio: The mass to charge ratio on a mass spectrum. For 1+ ions, this is equivalent to the mass of the ion.

Wavenumber: Represents the energy and frequency of infrared radiation absorbed by a bond in a molecule. This is the x-axis on IR spectra.